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EVALUATION OF POLYMERS AND FILTRATION PERFORMANCE OF BRAZILIAN BLEACHING CLAY

R. Frenette

August 1986

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EVALUATION OF POLYMERS AND FILTRATION PERFORMANCE OF BRAZILIAN BLEACHING CLAY

by

R. Frenette*

ABSTRACT

An evaluation of suitable potable grade flocculants for filtration-separation of an edible oil-clay suspension has been performed using flocculation, filtration rate, which was determined by filtrate volume/unit time, and clarity of filtrate measured using a conventional wedge apparatus. Of all the polymers tested, Praestol 2515TR, a potable grade flocculant, gave the best results for both 'Aporofo N' and 'Aporofo F' clay samples. This reagent gave filtration rates that were five and nine times higher than the unflocculated suspensions of 'Aporofo N' and 'Aporofo F', respectively. Clarity of filtrate produced by Praestol 2515TR was twice that of the unflocculated suspensions for both clays.

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INTRODUCTION

The purpose of this study was to find suitable potable grade flocculants that would give high filtration rate and a clear filtrate in the recovery of edible oil from a bleaching process using clay. It is known that filtration processes can be improved and otherwise difficult separations made possible by submitting the material to some form of pretreatment prior to filtration. The aim of pretreatment is to modify the properties of the material in a way to increase cake permeability and/or to prevent blinding of the medium. Among the pretreatment techniques are those employing coagulation with salts and flocculation with polymers to increase the state of aggregation of the particles comprising the filter cake.

Screening of flocculants was performed by using nonpotable grade flocculants available in the laboratory (Devon Coal Research Centre), and then the equivalent potable grade flocculants obtained from their respective suppliers and/or manufacturers. To evaluate the performance of the flocculants, the following parameters were measured: sediment height of the settled flocs in the beaker, clarity of the collected filtrate, and filtration rate of the flocculated clay/oil suspension.

Supplementary analyses on the clays are included for information purposes in Appendix C.

EXPERIMENTAL

MATERIAL

Two bags of Brazilian raw clay were submitted by Luscar Ltd for the test work. One was labelled "Santa Fe Clay, Aporofo N", and the second was labelled "Santa Fe Clay, Aporofo F". The company stated that these samples were basically the same material, the only difference being that the Aporofo F clay had been ground finer.

The soybean cooking oil was a commercial brand purchased locally. The oil was already refined and bleached, had a very light yellow color and was completely free of suspended particles.

Several potable and nonpotable grade commercial polymers ranging from 62-100% polyacrylamide were evaluated in the study. The trade names and

some characteristics of the flocculants tested are given in Table 1. These data have been taken from product information bulletins published by the manufacturers.

APPARATUS AND METHODS

The Buchner funnel apparatus employed in the filtration tests is shown in Fig. 1. Whatman filter paper #541 and a vacuun of 368 mm of mercury (7.5 psi) was used throughout.

To prevent ageing effects that reduce flocculant performance, freshly prepared solutions (0.1% by weight in deionized water) were used. Five percent (5% by weight) suspensions were prepared by slowly adding the clay to oil in 250 ml beakers and using mechanical stirring at 500 rpm for 5 minutes. A predetermined flocculant dosage of 0.8 kg/tonne of clay was then added in small increments with stirring at 900 rpm for 3 minutes to ensure uniform distribution of the flocculant throughout the suspension. Stirring was then continued for another 2 minutes at a reduced speed of 200 rpm.

After 30 minutes of undisturbed settling the height of the sedimented flocs in the beaker was measured in millimeters. The filtration rate was determined by measuring the volume in ml of filtrate collected as a function of time. The filtrate was then poured into a conventional wedge apparatus and the clarity taken as the highest number that could be read through the filtrate.

RESULTS AND DISCUSSION

The potable grade flocculants tested in the study were Praestol 2515TR, Praestol 2530TR, Praestol 2540TR, Separan NP10 and Percol LT20. The nonpotable grades tested were Percol 351, Percol E10, Praestol 2810, Superfloc N100S and Separan MGL.

Performance data for both grades of flocculants on 'Aporofo N' clay are summarized in Table 2. Clarity of filtrates ranged between wedge number 20 and 40, the untreated clay/oil suspension giving the lowest reading and those using Praestol 2515TR and 2540TR giving the best clarity and highest wedge readings. The untreated suspension had a sediment height of 6 mm as compared to the highest heights of 15 mm obtained with Praestol 2515TR and

2540TR. Of the two, however, Praestol 2515TR gave the highest filtration rate amounting to 0.40 ml/sec and correspondingly, the lowest specific resistance, 0.96 x 10^4 s^2/g, which reflects relatively good cake permeability. Sediment heights for the remanining potable grade flocculants were in the range of 11 to 14 mm and differed little from the heights of 11 to 13 mm obtained for the nonpotable grade flocculants. Filtration rates of all the treated clay/oil suspensions varied between 0.12 and 0.40 ml/sec. These results compared to the rate of 0.09 ml/ssec for the untreated suspension whose specific resistance was also the highest (5.10 x 10^4 s^2/g). The poorest filtration and clarity results were obtained with the two potable grade flocculants Separan NP10 and Percol LT20 which also showed high specific resistance of the cake (4.51 x 10^4 and 4.07 x 10^4 s^2/g, respectively).

Table 3 summarizes performance of the flocculants on the finer 'Aporofo F' clay. For this clay, all polymers produced large, fluffy flocs and clearer supernatants (even before filtration) compared to the 'Aporofo N' clay. The relative size of the flocs is reflected in the observed sediment heights recorded in the Table. Clarity for the filtrates of 'Aporofo F' clay/oil suspensions varied in the range of wedge no. 18 to 40. The untreated suspension had the lowest clarity while those treated with Praestol 2515TR and 2540TR again gave the highest clarity readings. As for clay N, addition of flocculant resulted in significant increase in sediment height over the untreated clay/oil suspension and again, Praestol 2515TR was, among others, the one giving the most voluminous sediment. The highest filtration rate of 0.44 ml/sec and the lowest specific resistance of 0.789 x 10^4 s^2/g was obtained with Praestol 2515TR which ranked along with 2540TR in giving the best clarity (wedge No. 40). The lowest filtration rates, as in the case of clay 'N', were obtained with potable grade flocculants Separan NP10 and Percol Lt20 (0.14 and 0.13 ml/sec, respectively) and the highest specific resistances of cake (3.99 x 10^4 and 3.01 x 10^4 s^2/g).

Figures 2-5 illustrate the effects of the various flocculants on the filtration rates of the two clay samples. It is noted that the untreated suspension of 'Aporofo F' clay had a much lower filtration rate than the untreated suspension of 'Aporofo N' clay. This could be attributed to the finer size consist of 'Aporofo F' wherein colloidal particles clog the

interstices in filter cake and blind the filter medium. The filtration curves also show that there was very little decrease of filtering rate with time so that the filtration rates given in Tables 2 and 3 can be taken as representing an average rate.

The plots in Fig. 6-9 show the specific resistances for the 'Aporofo N' and 'Aporofo F' clays and allow comparisons between the untreated samples and those treated with the nonpotable and potable grade flocculants. Figure 6 shows that, for sample 'N', the three Praestol potable grade flocculants are distinctly better than the other two reagents, Separan NP10 and Percol LT20. Figure 8 shows that, the nonpotable Percol E10 and Superfloc N100S were better than the others, but also show smaller differences in performance overall. For the 'Aporofo F' sample, in Fig. 7, the three Praestol potable grade flocculants were distinctly better that other two reagents. For the nonpotable grade flocculants, as shown in Fig. 9, although Superfloc N100S gave best permeability the differences among the flocculants was not as significant as for clay 'N'.

CONCLUSIONS

The following conclusions can be drawn:

1. In adding the aqueous flocculant solution into the clay/oil suspension, stirring the suspension vigorously while slowly adding the flocculant is an important step to follow in order to ensure that the flocculant is distributed uniformly throughout the suspension. Unless this is done water globules will be observed in the suspension.
2. Addition of flocculants is needed to obtain good filterability and filtrate clarity for both clays.
3. Of the polymers tested, potable grade Praestol 2515TR was the most effective one for both clay irrespective of the fineness of grind.
4. For 'Apoforo N', Praestol 2515TR provided a two-fold increse in clarity and a five-fold increase in filtration rate over the unflocculated suspension. For 'Aporofo F', this reagent also produced a two-fold increase in clarity, but a significantly better filtration rate as shown by a nine-fold increase over the unflocculated suspension.

REFERENCES

1. Eldin, K. Ali "Feasibility study on bleaching of luba and vegetables oils by Brazilian clay"; Luscar Ltd., August 1982.
2. Grim, R.E. "Clay mineralogy"; New York, McGraw-Hill, 1968.
3. Schwoyer, W.L.K. "Polyelectrolytes for water and wastewater treatment"; Boca Raton, Florida, CRC Press; 1968.

Table 1 Characteristic Properties of the Polymer Flocculants for Clay/Oil Suspensions

Polymer	Ionic Characterization	Molecular Weight	Application	Form	Manufacturer
Percol 351	100% PAM	V. High	Nonpotable	solid	Allied Colloids
Percol E-10	95% PAM	High	Nonpotable	"	Allied Colloids
Praestol 2810	98-99% PAM	$4\text{-}6X10^6$	"	"	Stockausen
Superfloc N100S	100% PAM	$15X10^6$	"	"	Cyanamid
Separan MGL	96% PAM	$2\text{-}3X10^6$	"	"	Dow Chemicals
Praestol 2515TR	88% PAM	$4\text{-}5X10^6$	Potable	"	Stockausen
Praestol 2530TR	75% PAM	$4\text{-}5X10^6$	"	"	"
Praestol 2540TR	62% PAM	$4\text{-}5X10^6$	"	"	"
Separan NP20	97% PAM	High	"	"	Dow Chemicals
Percol LT20	100% PAM	$>7X10^6$	"	"	Allied Colloids

Table 2 Performance of the Different Flocculants on "Aporofo N" clay.

Polymer	Clarity (wedge #)	Sediment (mm)	Filtration Rate (ml/sec)	Specific Resistance (s^2/g)
	20	6.0	0.09	$5.19X10^4$
Percol 351	33	11.0	0.20	$2.20X10^4$
Percol E-10	35	13.0	0.34	$1.20X10^4$
Praestol 2810	35	12.0	0.21	$2.37X10^4$
Superfloc N100S	35	12.0	0.34	$1.08X10^4$
Separan MGL	35	12.0	0.17	$2.33X10^4$
Praestol 2515TR	40	15.0	0.40	$0.96X10^4$
Praestol 2530TR	35	14.0	0.37	$1.00X10^4$
Praestol 2540TR	40	15.0	0.36	$1.20X10^4$
Separan NP10	25	11.0	0.12	$4.51X10^4$
Percol LT20	30	12.0	0.13	$4.07X10^4$

* Taken as average

Table 3 Performance of the Different Flocculants on "Aporofo F" clay.

Polymer	Clarity (wedge #)	Sediment (mm)	Filtration Rate (ml/sec)	Specific Resistance (s^2/g)
	18	10.0	0.05	$10.84X10^4$
Percol 351	35	15.0	0.23	$2.08X10^4$
Percol E-10	35	16.0	0.28	$1.41X10^4$
Praestol 2810	35	17.0	0.27	$1.75X10^4$
Superfloc N100S	35	17.0	0.35	$1.25X10^4$
Separan MGL	35	16.0	0.27	$1.45X10^4$
Praestol 2515TR	40	17.0	0.44	$0.79X10^4$
Praestol 2530TR	35	17.0	0.35	$1.25X10^4$
Praestol 2540TR	40	17.0	0.33	$1.41X10^4$
Separan NP10	30	15.0	0.14	$3.99X10^4$
Percol LT20	33	15.0	0.13	$3.01X10^4$

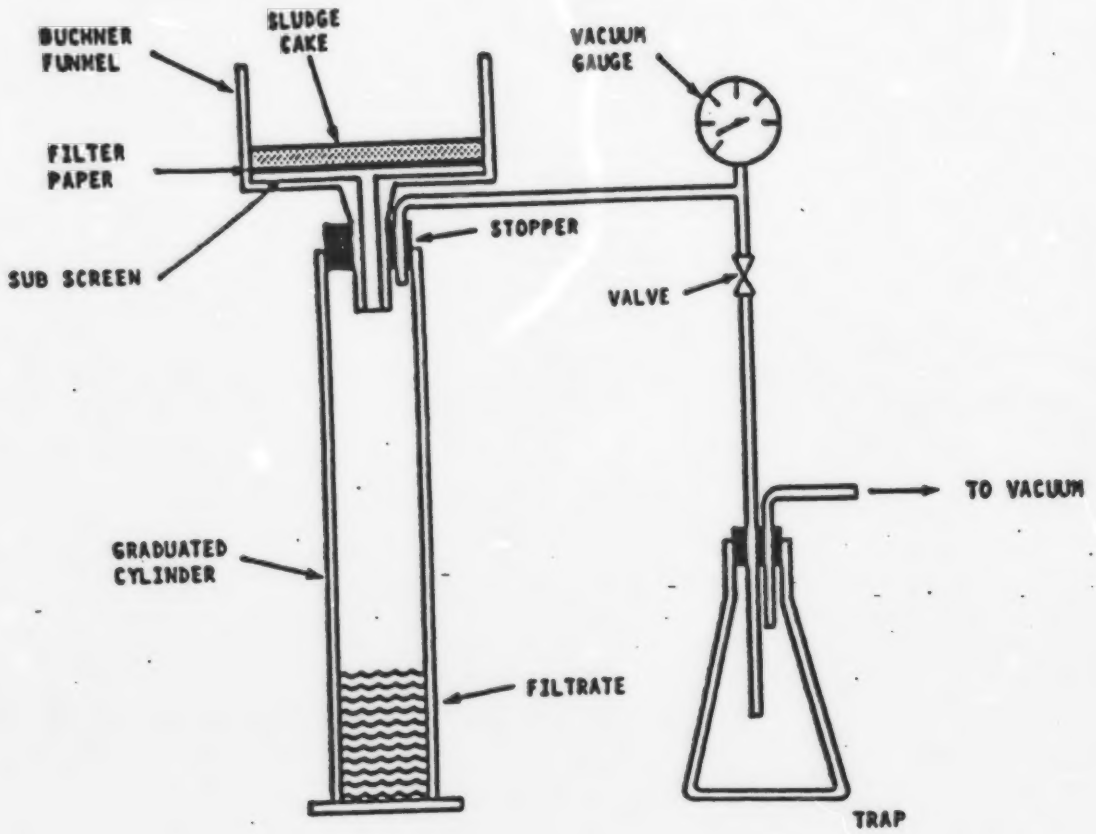

Figure 1. Schematic diagiam of filtration test apparatus.

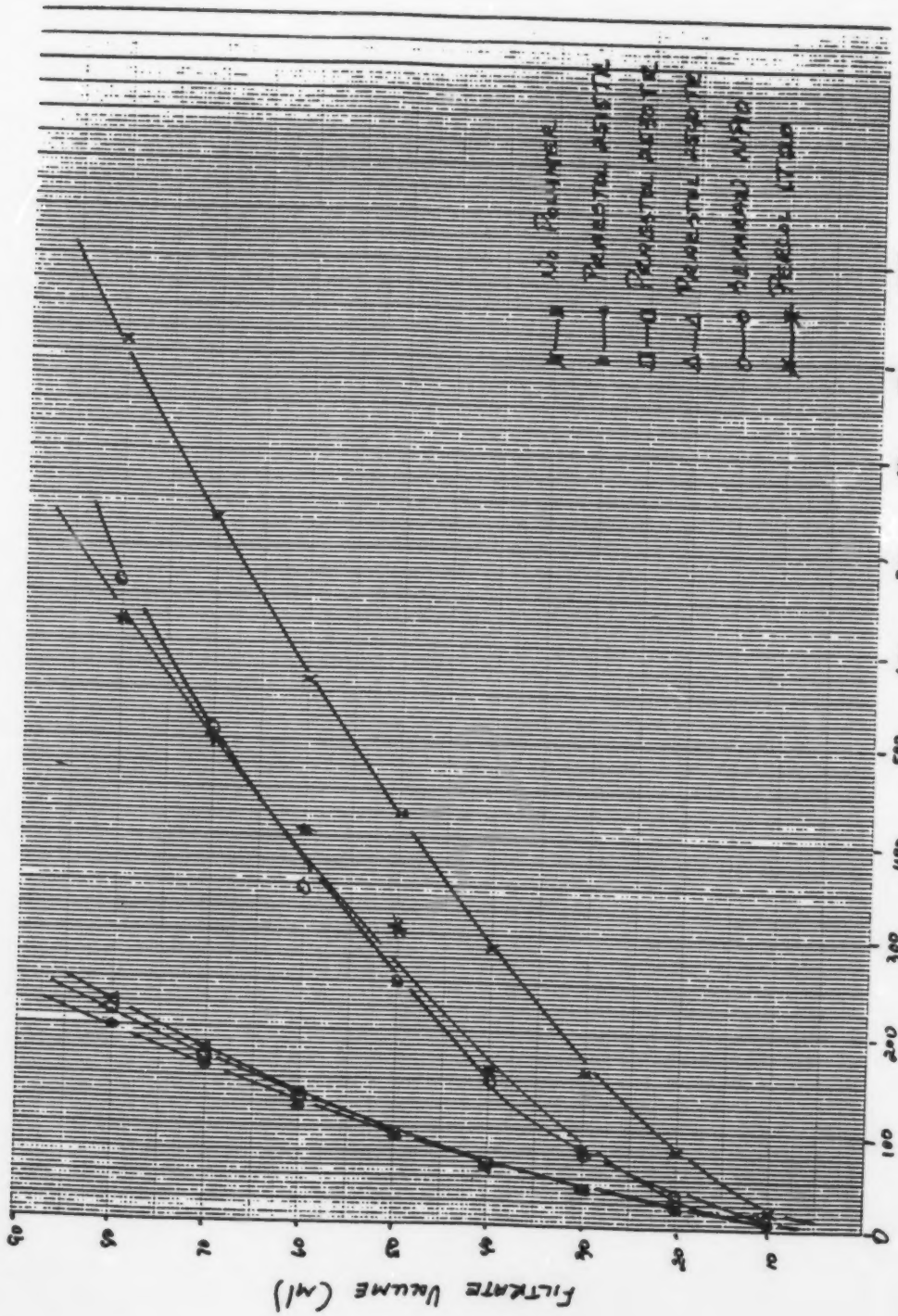

Figure 2. Filtration rate of "Aporofo N" clay untreated and treated with potable flocculants.

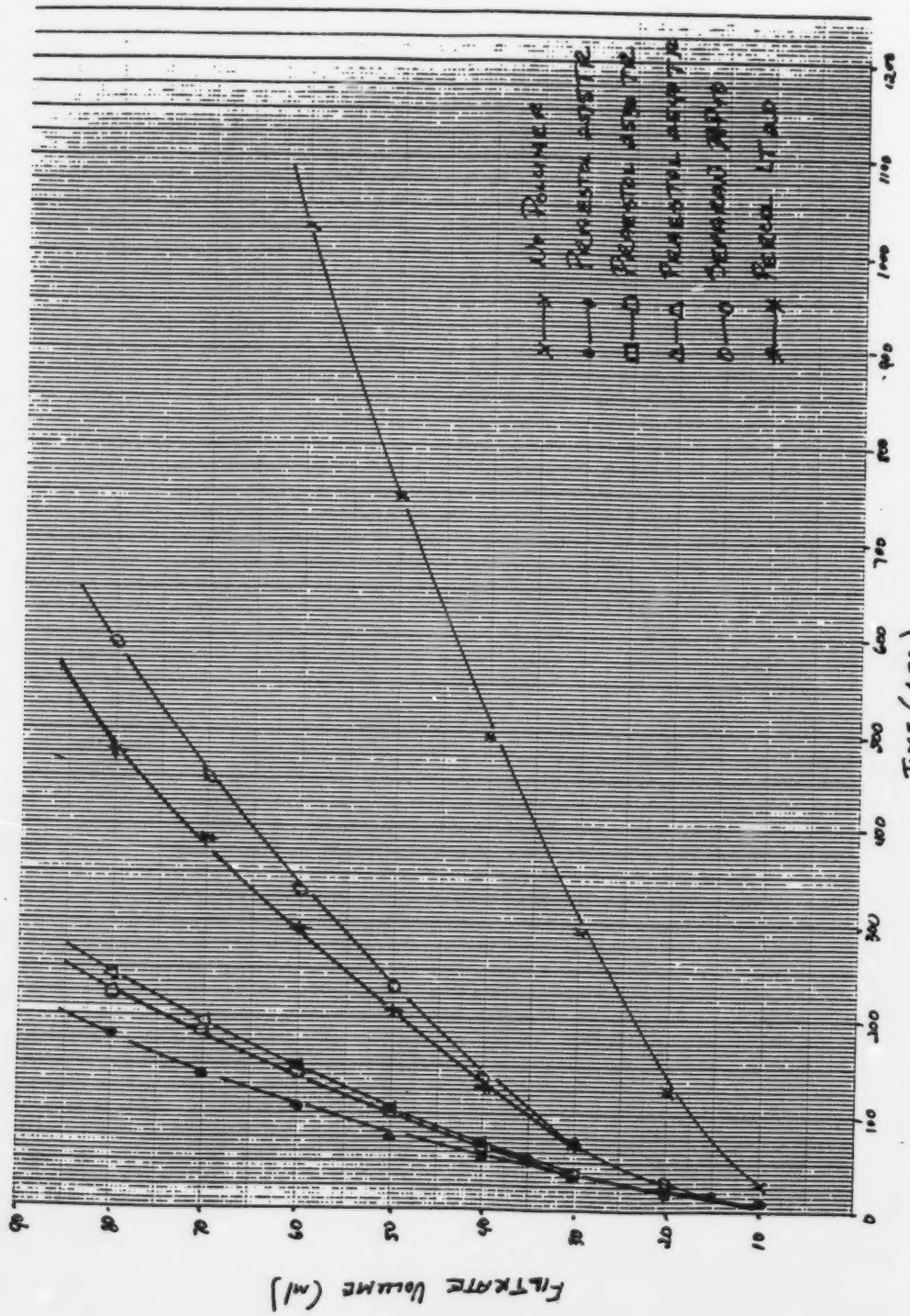

Figure 3. Filtration rate of "Aporofo F" clay untreated and treated with potable flocculants.

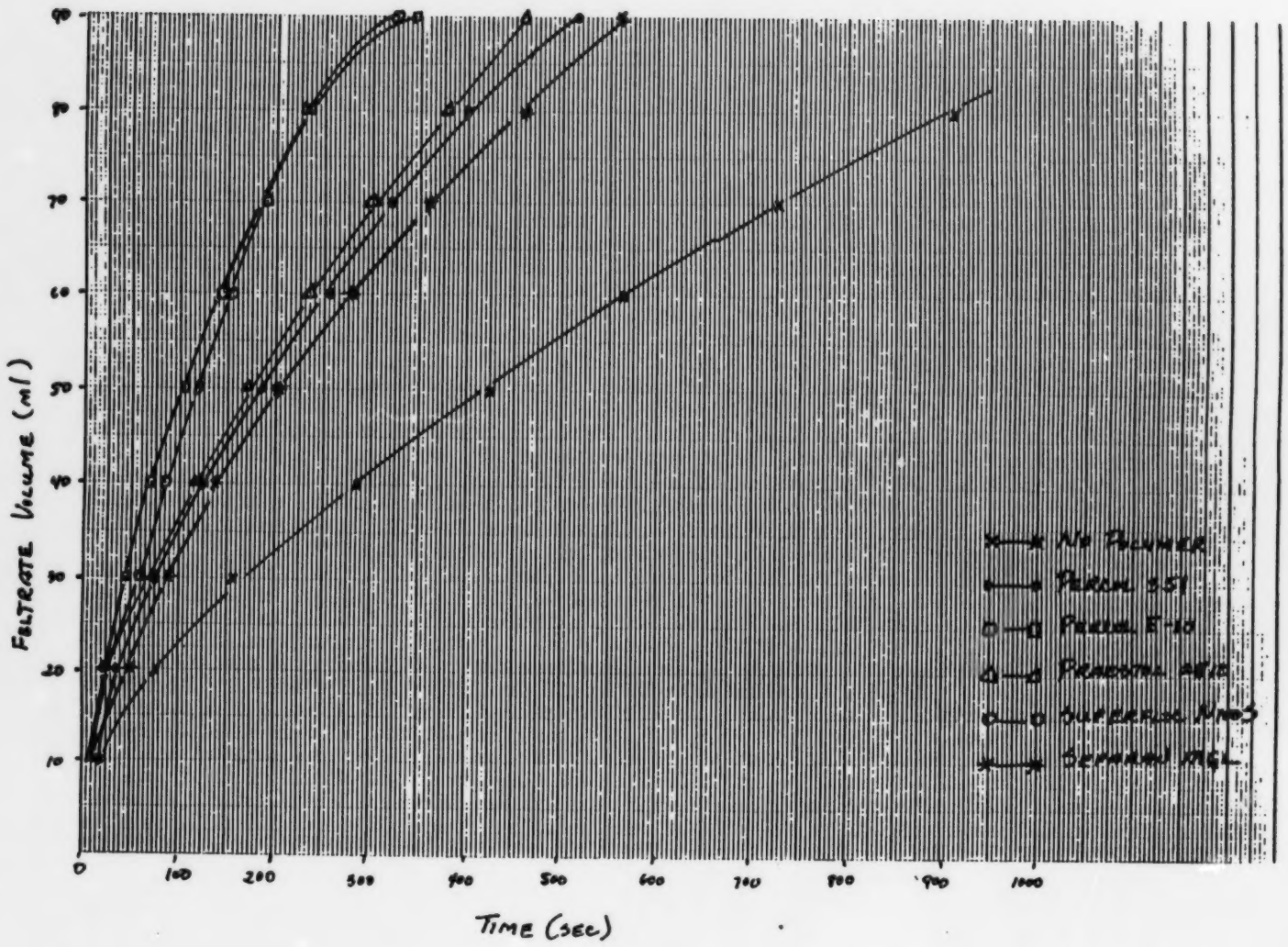

Figure 4. Filtration rate of "Aporofo N" clay untreated and treated with nonpotable flocculants.

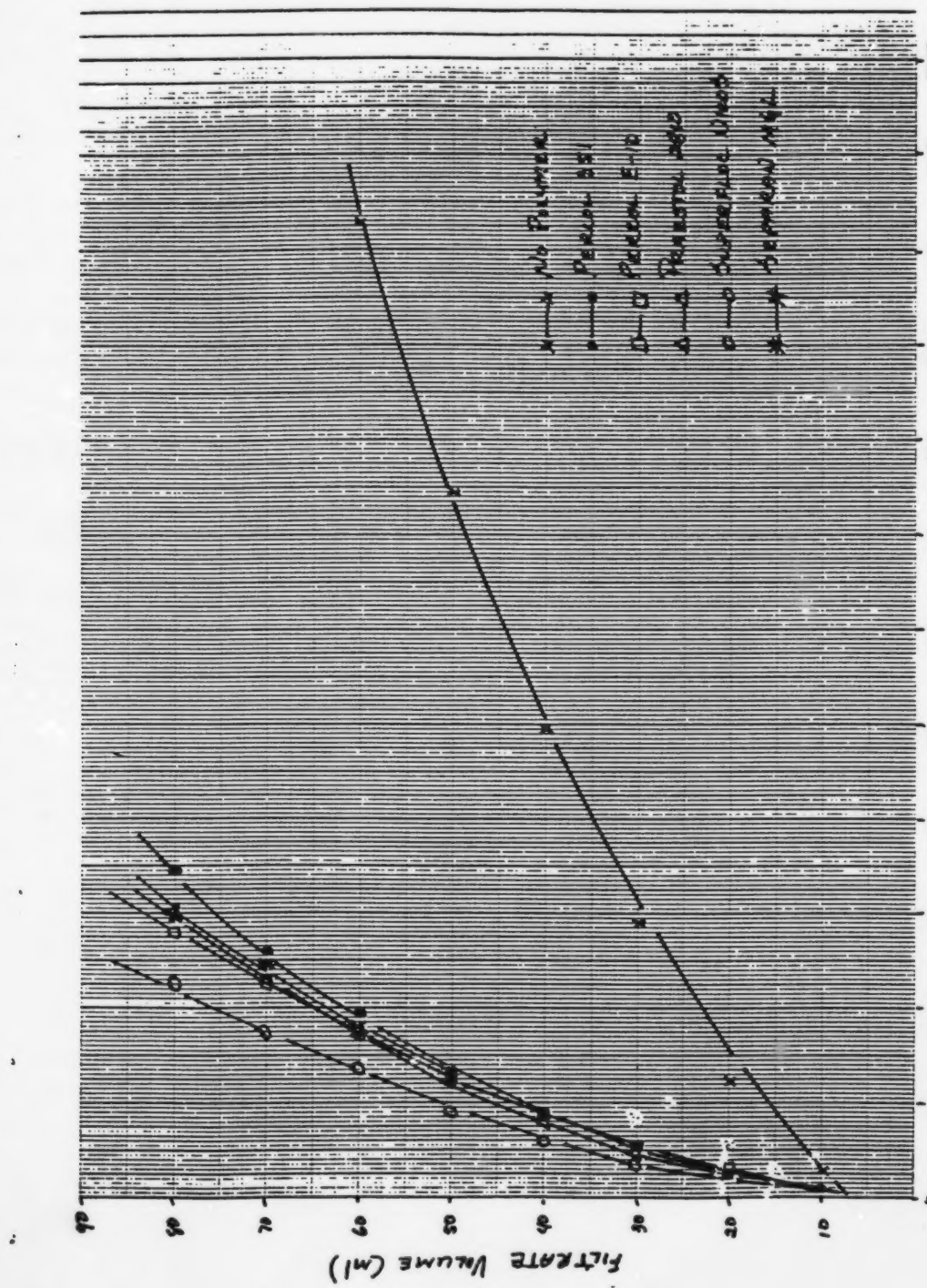

Figure 5. Filtration rate of "Aporofo F" clay untreated and treated with nonpotable flocculants.

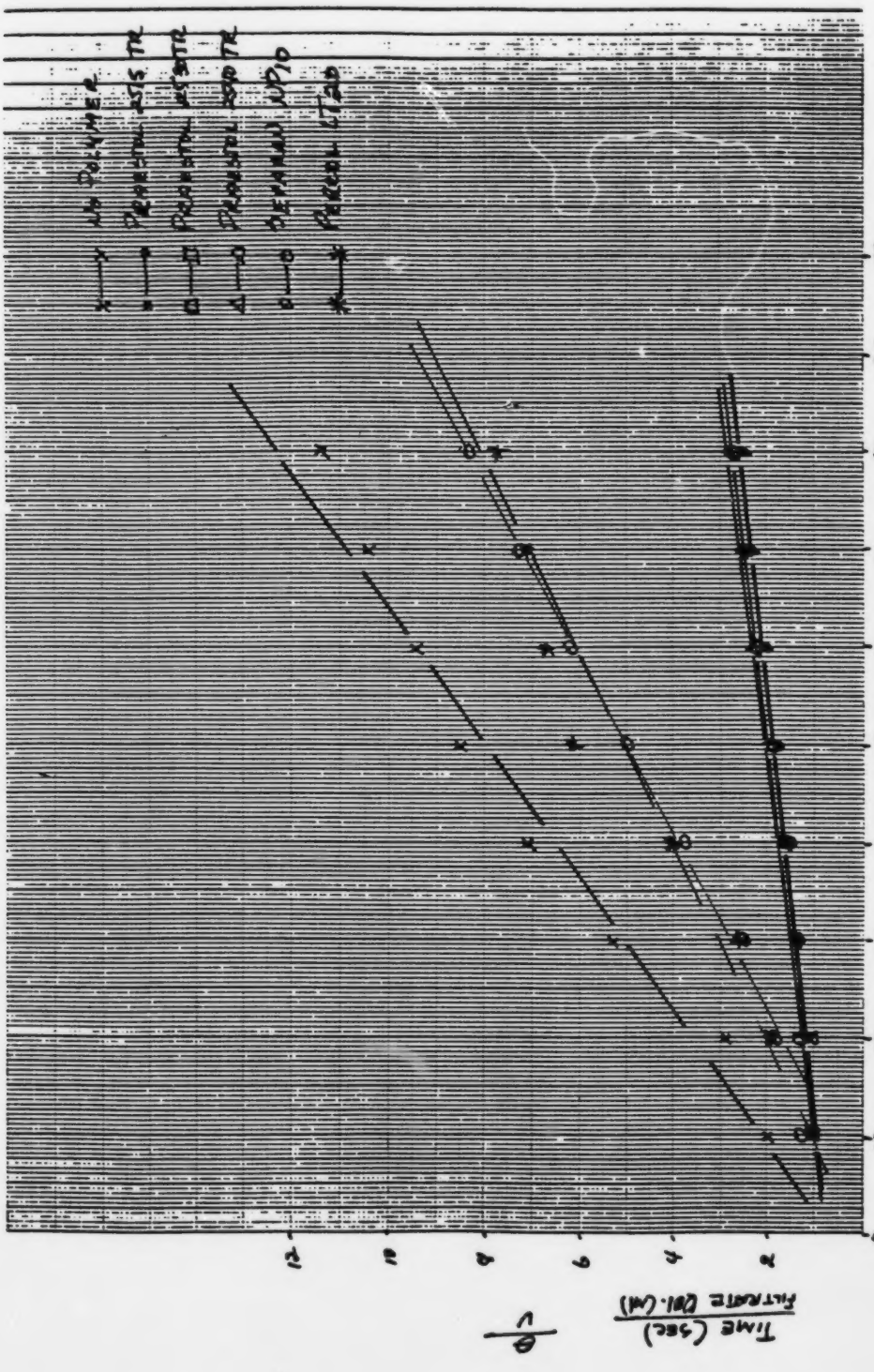

Figure 6. Specific resistance of "Aporofo N" clay untreated and treated with potable flocculants.

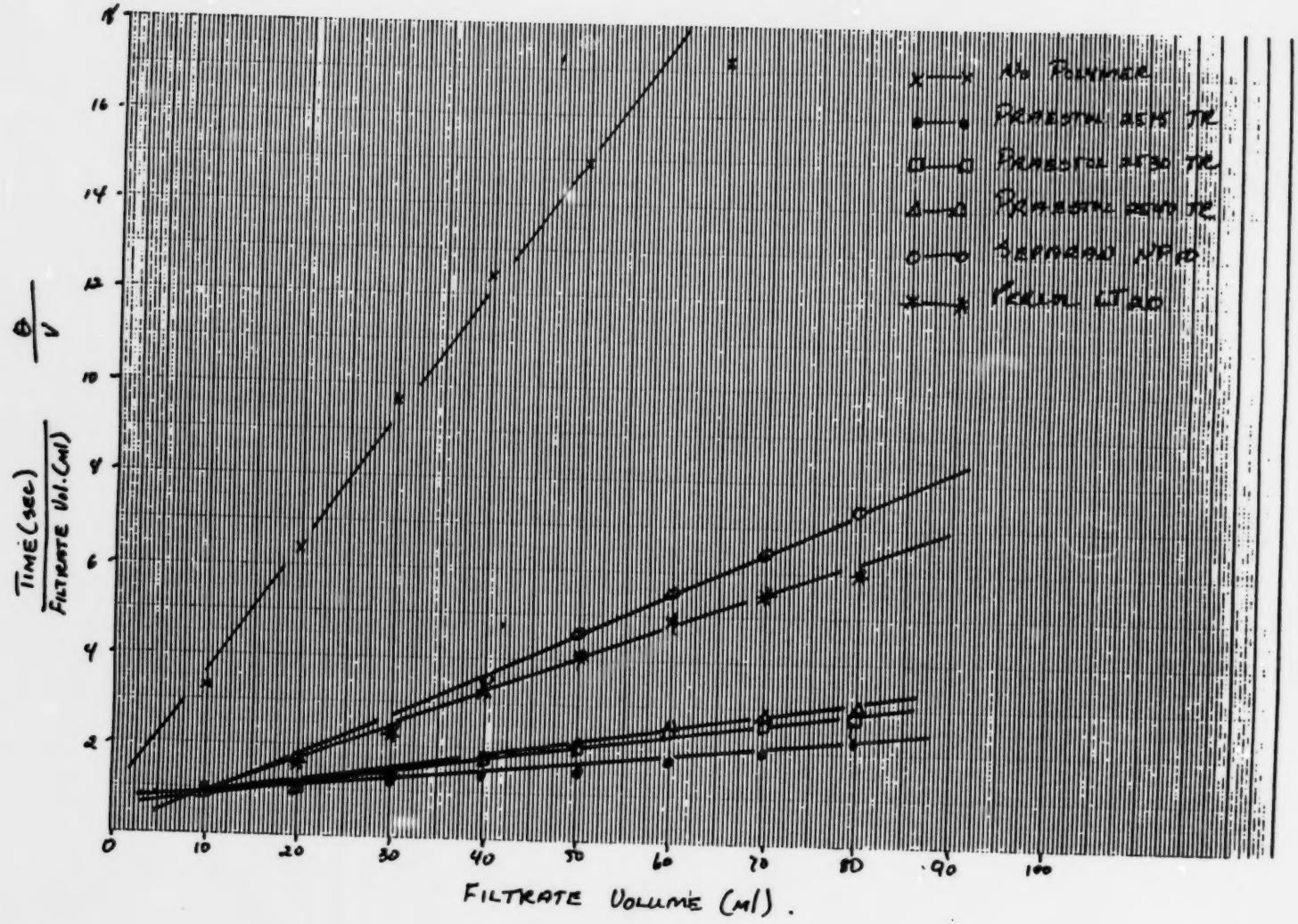

Figure 7. Specific resistance of "Aporofo F" clay untreated and treated with potable flocculants.

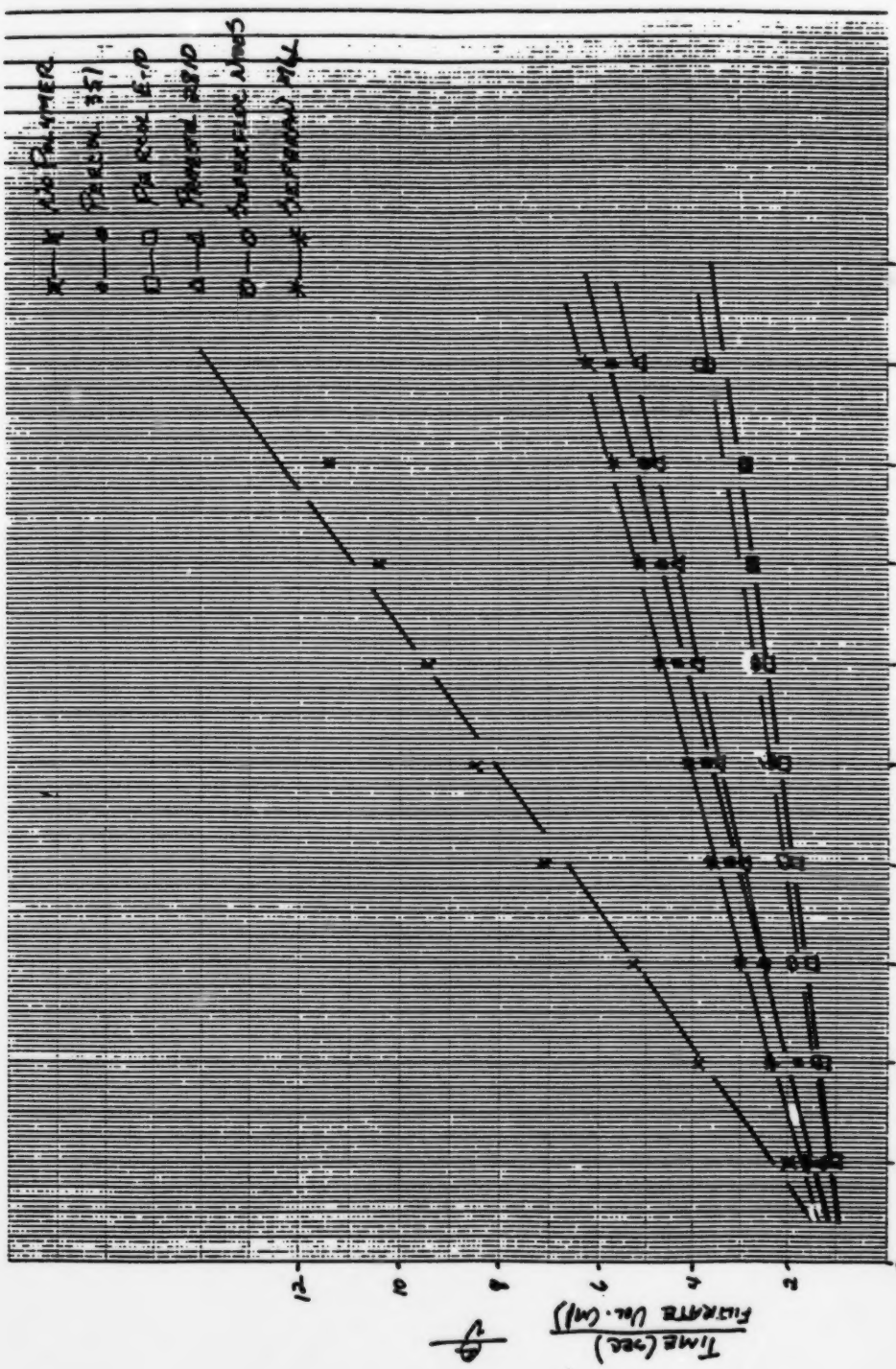

Figure 8. Specific resistance of "Aporofo N" clay untreated and treated with nonpotable flocculants.

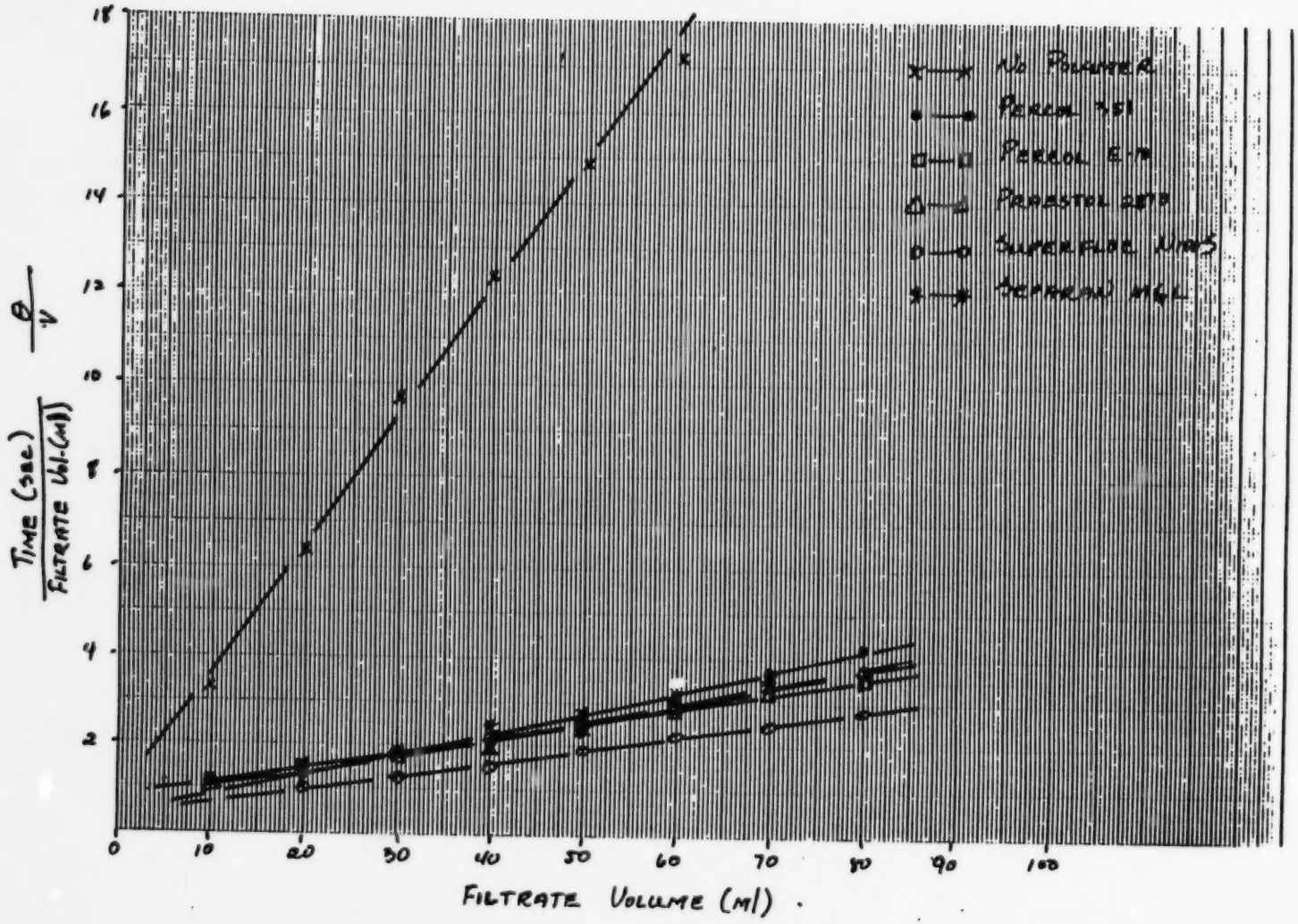

Figure 9. Specific resistance of "Aporofo F" clay untreated and treated with nonpotable flocculants.

APPENDIX A

Alberta
ENVIRONMENT
Environmental Protection Services
Standards and Approvals Division
Municipal Engineering Branch

9820 - 106 Street, Edmonton, Alberta, Canada T5K 2J6 403/427-5877 Telex 037-2006 TWX 610-831-2636

Our File: 5015-5

August 27, 1985

Prairie Industrial Chemicals Inc.
4411 - 82 Avenue
EDMONTON, Alberta
T6B 0A9

Attention: Don Boisjoli, Sales Representative

Dear Sis:

Re: The Use of the Polyelectrolytes Praestol 2530 TR, 2540 TR and 2515 TR in Water Treatment Facilities in Alberta

Based on our recent telephone conversation and your August 23, 1985 letter and information on the aforementioned products, this letter will confirm that our Division has no objection to the use of the following three polyacrylamide based organic, synthetic flocculants in potable water applications in Alberta:

i) Praestol 2530 TR;

ii) Praestol 2540 TR; and

iii) Praestol 2515 TR.

This "no objection to use" statement is based on the January 23, 1985 approval of these products by the Science and Technology Branch of the U.S. Environmental Protection Agency (EPA). As per this EPA approval the maximum recommended feed rate of any of these three products should not exceed 1.0 mg/L. It should be noted that our "no objection to use" statement is not based on any evaluation or testing of these products by our Division and is based solely on the EPA approval for the products. Should your company receive or become aware of any additional or revised information on the safety of these products in potable water application, this information should be forwarded to our Division.

....2

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If you have any questions regarding the above, please do not hesitate to contact me at 427-5877.

Yours truly,

David Spink

David Spink, M.Sc., P. Eng.
Branch Head
Municipal Engineering Branch

c.c. M.S. McClure
S & A Regional Engineers

pdp/0792C

APPENDIX B

The name and address of Stockausen agency in Brazil:

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Industrias Quinicas
Aruja Ltda.
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7°Cj. 712
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Brazil

APPENDEIX C -- Supplementary Analyses on clay samples.

Table C-1. Cation Excahnge Capacity of 'Aporofo N' and 'Aporofo F' Clays (using Ammonia Orion Electrode Method based on the paper by E. Busenberg and C.V. Clemency, 1973.).

1. 'Aporofo N' = 13.7 meq/100 gm

2. 'Aporofo F' = 14.5 meq/100 gm

Table C-2. Variations in the Cation-Exchange Capacity of Kaolinite and Illite with Particle Size.

Variations in the cation-exchange capacity of kaolinite with particle size
(After Harmon and Fraulini[17])

Particle size, μ	10–20	5–10	2–4	1–0.5	0.5–0.25	0.25–0.1	0.1–0.05
Cation-exchange capacity, meq/100 g	2.4	2.6	3.6	3.8	3.9	5.4	9.5

Variations in the cation-exchange capacity of illite with particle size
(After Grim and Bray[18])

Particle size, μ	.....	1–0.1	0.1–0.06	−0.06
Cation-exchange capacity, meq/100 g	Sample *A*	18.5	21.6	33
	Sample *B*	13.0	20.0	27.5
	Sample *C*	20.0	30.0	41.7

Reference: Grim, R.E. "Clay mineralogy"; New York, McGraw-Hill, 1968.

Table C-3 Particle size distribution of 'Aporofo N' clay.

PARTICLE SIZE (um)	SIEVE	COULTER COUNTER	TOTAL	CUMULATIVE SIZE
+ 250	1.91		1.99	100.00
250 - 149	2.87		2.87	98.09
149 - 74	9.19		9.19	95.22
74 - 44	8.84		8.84	86.03
44 - 37	3.23	0.14	3.37	77.19
45.3 - 35.9		0.07	0.07	73.82
35.9 - 28.5		1.33	1.33	73.75
28.5 - 22.6		3.03	3.03	72.42
22.6 - 18.0		3.48	3.48	69.39
18.0 - 14.3		6.21	6.21	65.91
14.3 - 11.3		6.66	6.66	59.70
11.3 - 9.0		8.14	8.14	53.04
9.0 - 7.1		7.72	7.62	44.90
7.1 - 5.7		7.99	7.99	37.28
5.7 - 4.5		7.69	7.69	29.29
4.5 - 3.6		6.88	6.88	21.60
3.6 - 2.8		5.62	5.62	14.72
2.8 - 2.2		4.81	4.81	9.10
2.2 - 1.8		4.22	4.22	4.29
- 1.8		0.07	0.07	0.07
Total	26.04	73.96	100.00	100.00

Table C-4. Particle size distribution of 'Aporofo F' clay.

PARTICLE SIZE (um)	SIEVE	COULTER COUNTER	TOTAL	CUMULATIVE SIZE
+ 250	0.44		0.44	100.00
250 - 149	1.42		1.42	99.56
149 - 74	4.05		4.05	98.14
74 - 44	6.86		6.86	94.09
44 - 37	3.82	0.08	3.90	87.23
45.3 - 35.9		0.42	0.42	83.33
35.9 - 28.5		2.75	2.75	82.91
28.5 - 22.6		4.84	4.84	80.16
22.6 - 18.0		4.84	4.84	75.32
18.0 - 14.3		6.92	6.92	70.48
14.3 - 11.3		8.09	8.09	63.56
11.3 - 9.0		9.52	9.52	55.47
9.0 - 7.1		8.09	8.09	45.95
7.1 - 5.7		8.42	8.42	37.86
5.7 - 4.5		7.76	7.76	29.44
4.5 - 3.6		6.92	6.92	21.68
3.6 - 2.8		5.59	5.59	14.76
2.8 - 2.2		4.84	4.48	9.17
2.2 - 1.8		4.25	4.25	4.33
-1.8		0.08	0.08	0.08
Total	16.59	83.41	100.00	

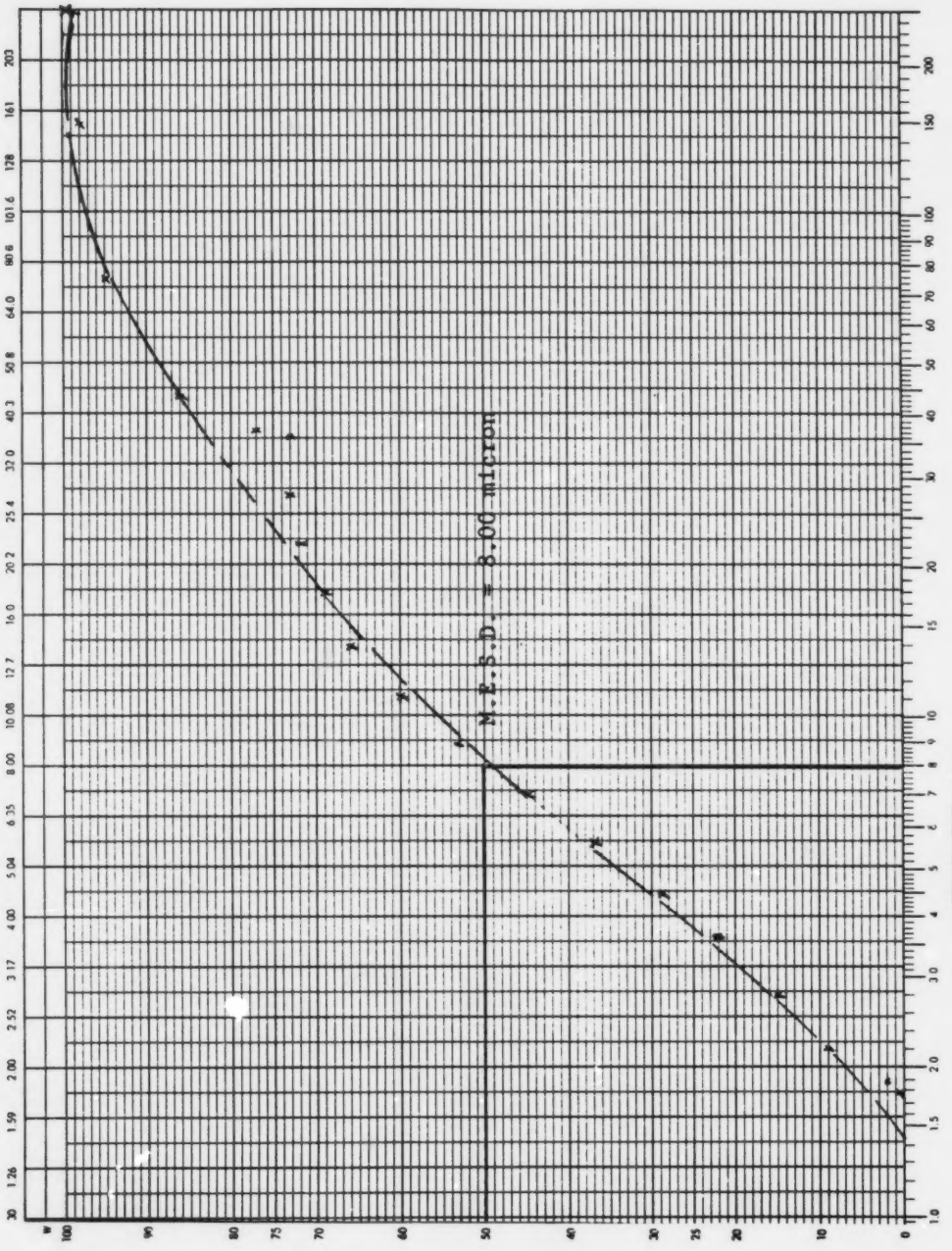

Fig. C-1. Cummulative sizerdistribution plot of 'Aporofo N' clay.

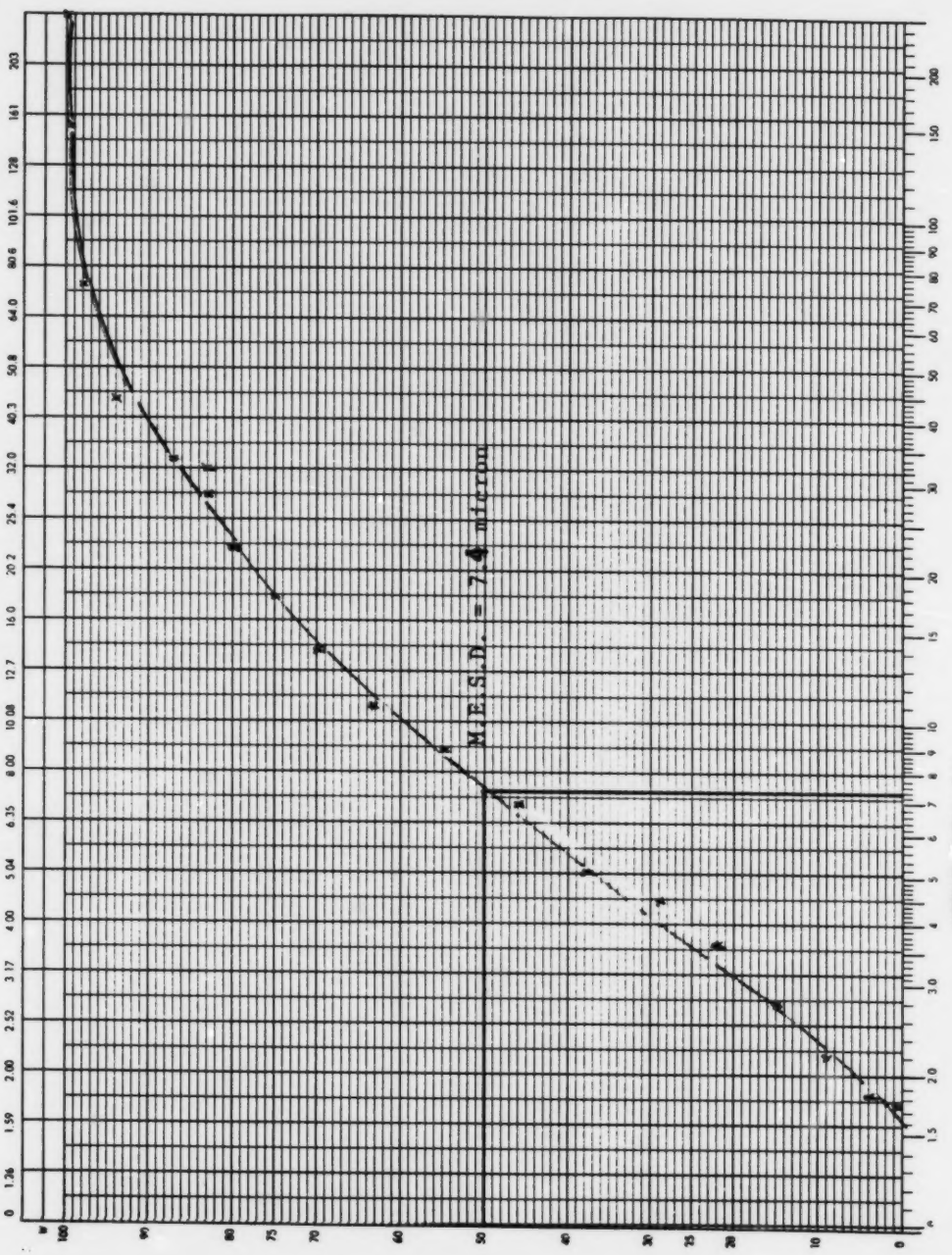

Fig. C-2. Cummulative size distribution plot of 'Aporofo F' clay.

THE FOLLOWING FIT IS FROM DATA POINT 1
SAMPLE: SANTA FE CLAY - PARTICLE SIZE [illegible] TO 30% - 'APOPOFO N' LUSCAR CLAY, JULY
11/86 [illegible]
W1=22.6222 H1=550.20 V1=131.40 PS=720.2760
W2=21.5995 H2=152.89 ALPHA=5.60E-03
WS= 1.0227 TS= 76.89 VD=30.10 S=16.2
B= .09010
C=5.3063E-06
VS=18.2591

ITERATION	WHICH X	A	P1	P2	V	X	Y
1	1	.10460	150.0000	27.4500	28.1604	.0381	.0020
2	0	.03441	170.1600	49.8200	22.2756	.0692	.0033
3	0	.03441	180.0500	72.9000	23.8670	.1012	.0047
4	0	.03441	190.0200	94.1500	25.2312	.1307	.0060
5	0	.03441	200.0000	113.9600	26.3038	.1582	.0071
6	0	.03441	209.8800	132.3200	27.3731	.1837	.0082

m^2/gm

SW= 101.458
Standard error of least squares line = .0000
Error= .18 percent

THE FOLLOWING DATA IS FIT FROM DATA POINT 1
Linear model: Y=A+B*X
A= 3.53203726450E-04
B= 4.28947866981E-02

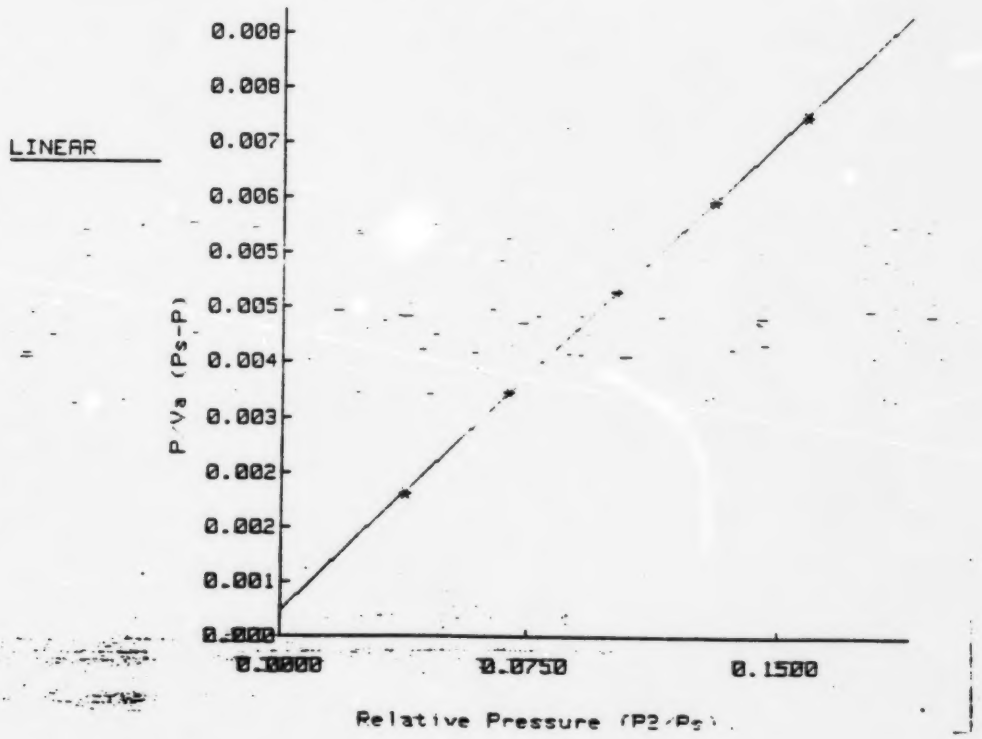

Fig. C-3. Surface area plot of 'Aporofo N' clay.

SAMPLE: SANTA FE CLAY - PARTICLE SIZE 85% TO 98% - 'APOROFO F' LUSCAR CLAY, JULY

11/86

W1=22.5185 H1=549.98 X1=131.40 PS=732.8900

W2=21.6956 H2=153.91 ALPHA=6.68E-05

WS= .8229 TS= 77.83 VB=28.10 S=16.2

B= .11887

C=6.7172E-06

VB=17.9553

ITERATION	WHICH ?	A	P1	P2	V	X	Y
1	1	.22942	158.9300	41.4300	20.5503	.0566	.0029
2	0	.04276	178.0700	64.9700	22.4365	.0887	.0043
3	0	.04276	188.6300	87.3900	23.9328	.1194	.0057
4	0	.04276	190.0000	108.0500	25.1358	.1476	.0069
5	0	.04276	200.0000	126.3200	26.2466	.1725	.0079

SW= 99.316 m^2/gm

Standard error of least squares line = .0000

Error= .29 percent

THE FOLLOWING DATA IS FIT FROM DATA POINT 1

Linear model: Y=A+B*X

A= 4.80936789060E-04

B= 4.33463819085E-02

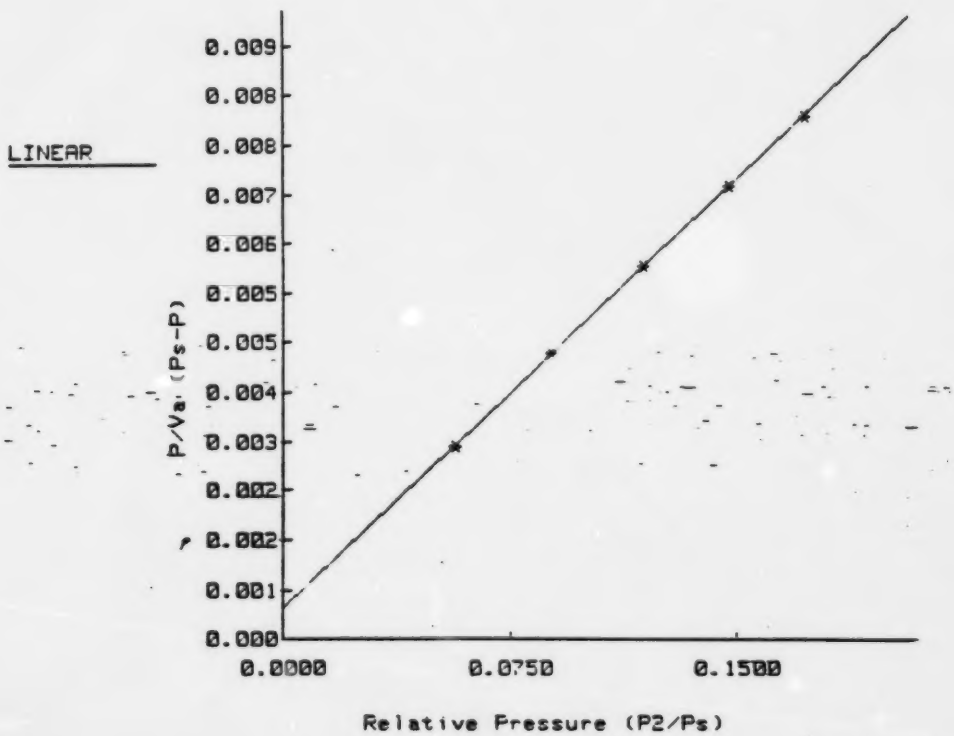

Fig. C-4. Surface area plot of 'Aporofo F' clay.

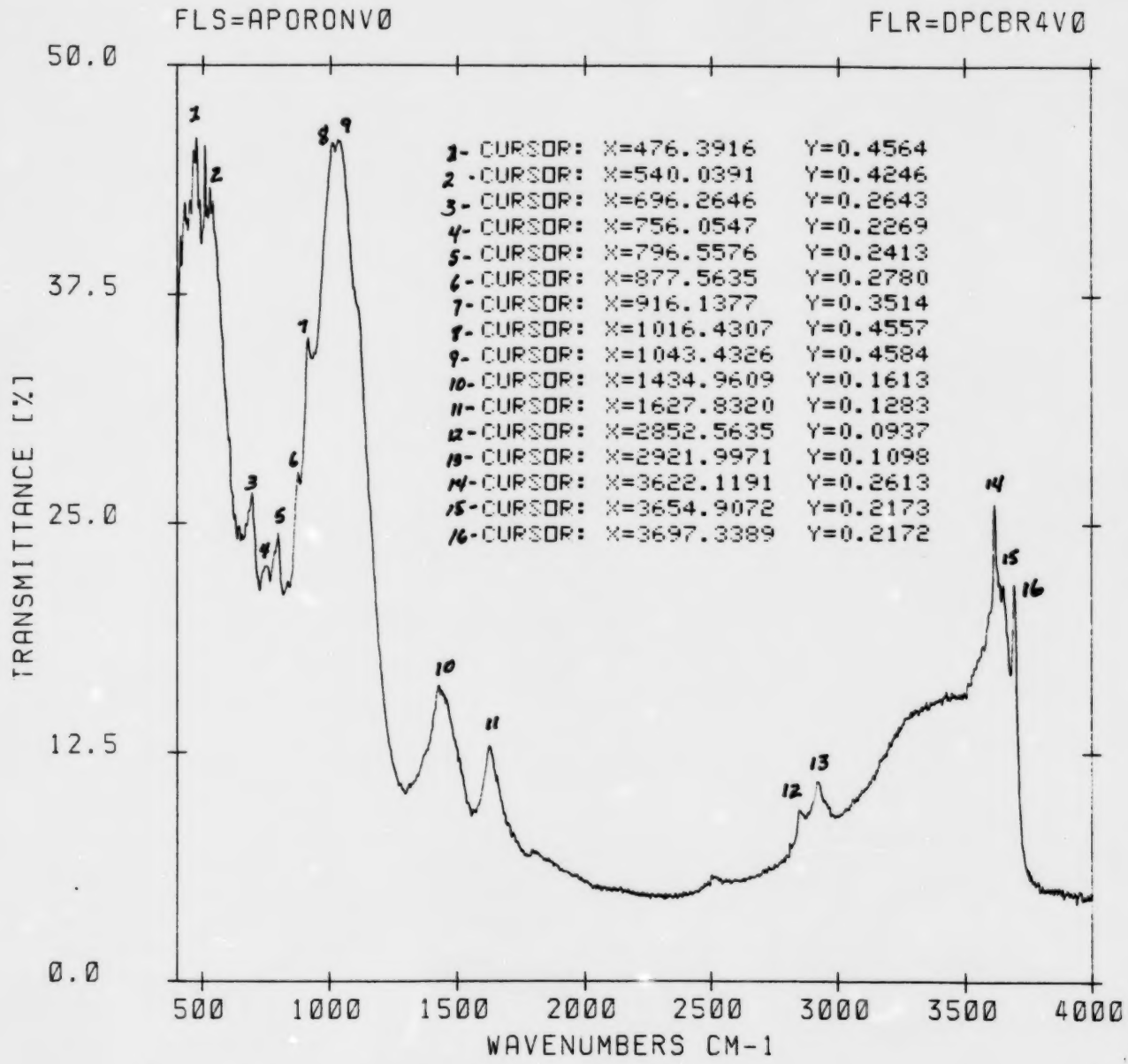

Fig. C-5. Mid-infrared photoacoustic spectrum of 'Aporofo N'.

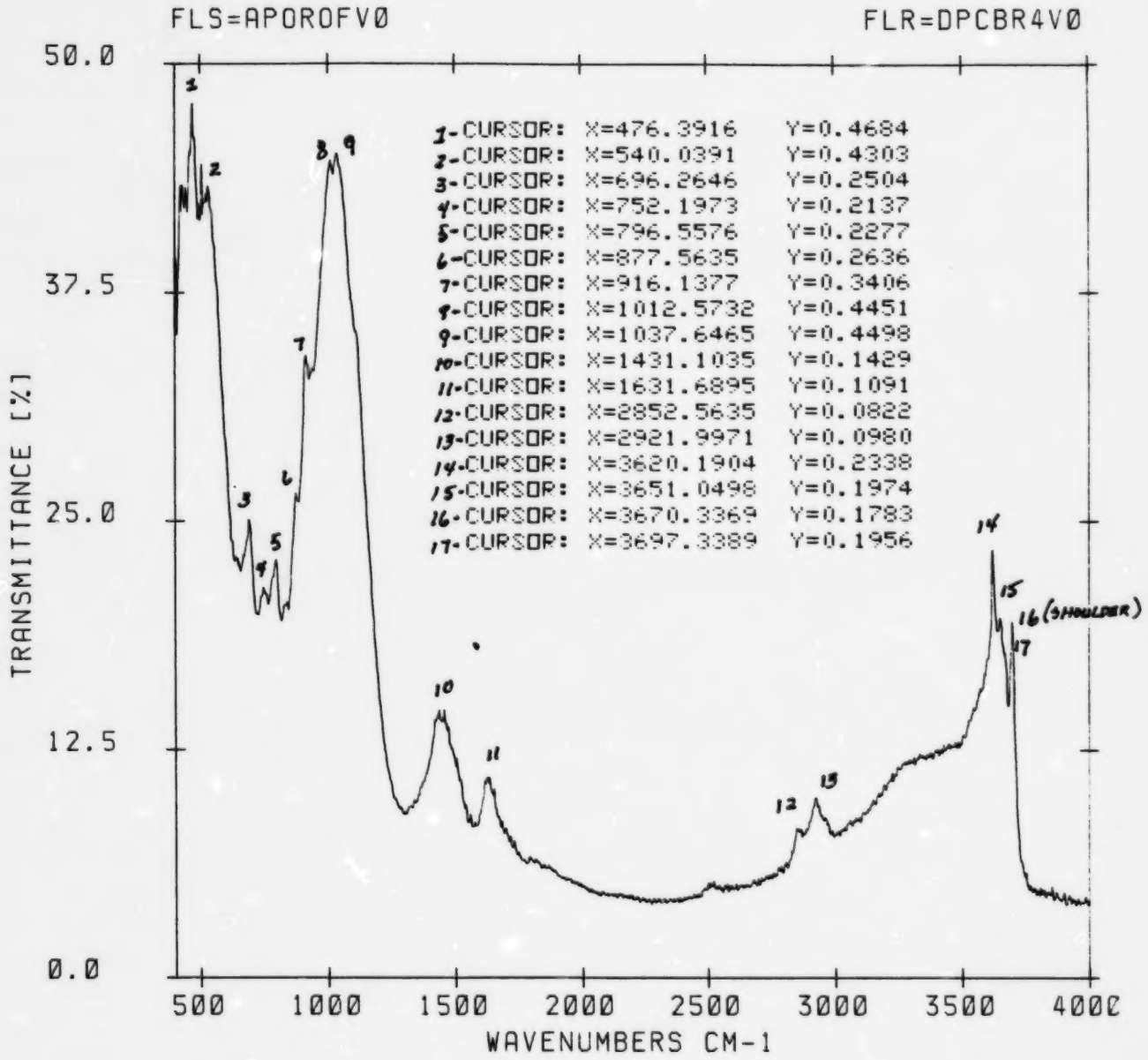

Fig. C-6. Mid-infrared photoacoustic spectrum of 'Aporofo F'.

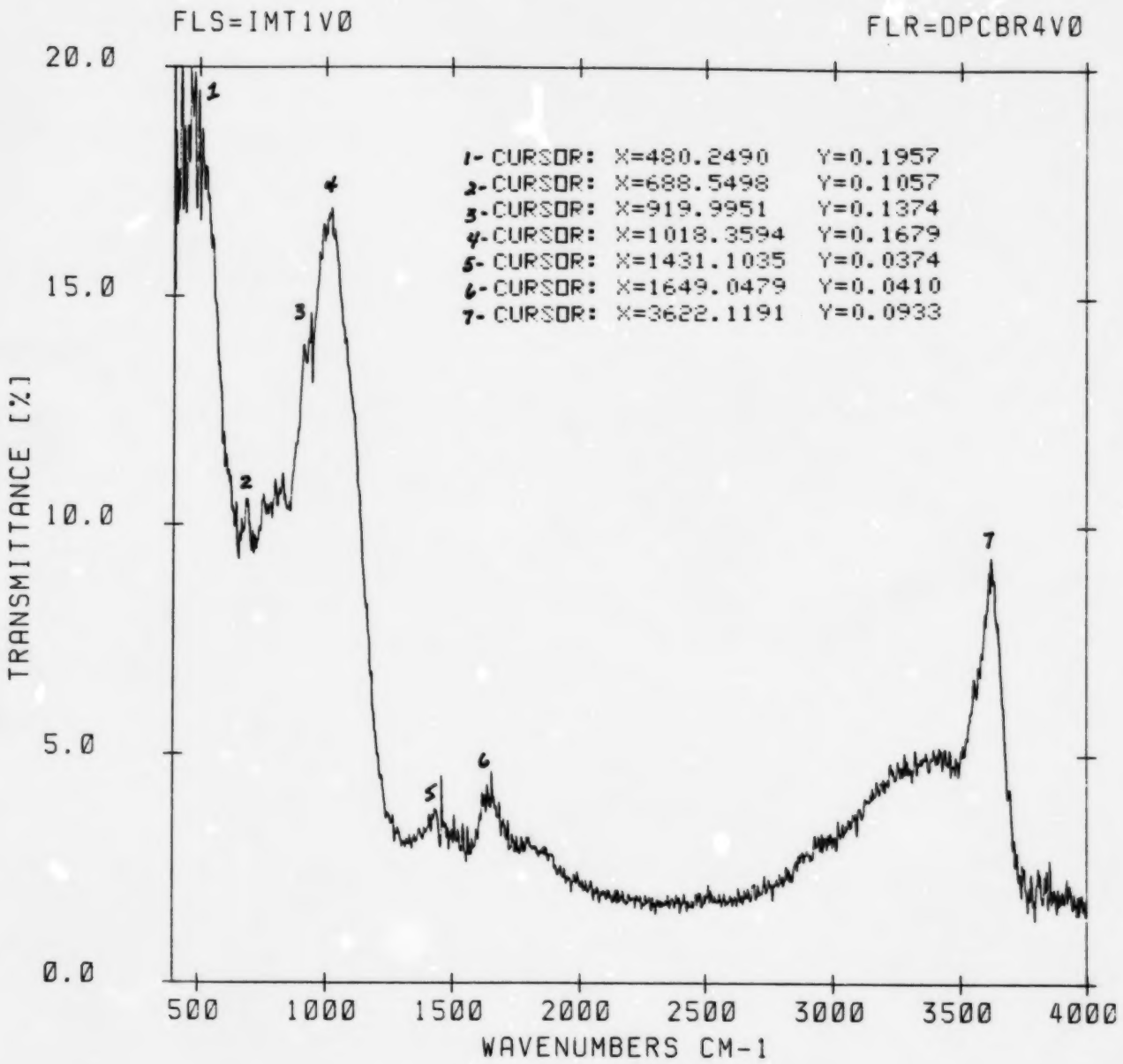

Fig.C-7. Mid-infrared photoacoustic spectrum of illite.

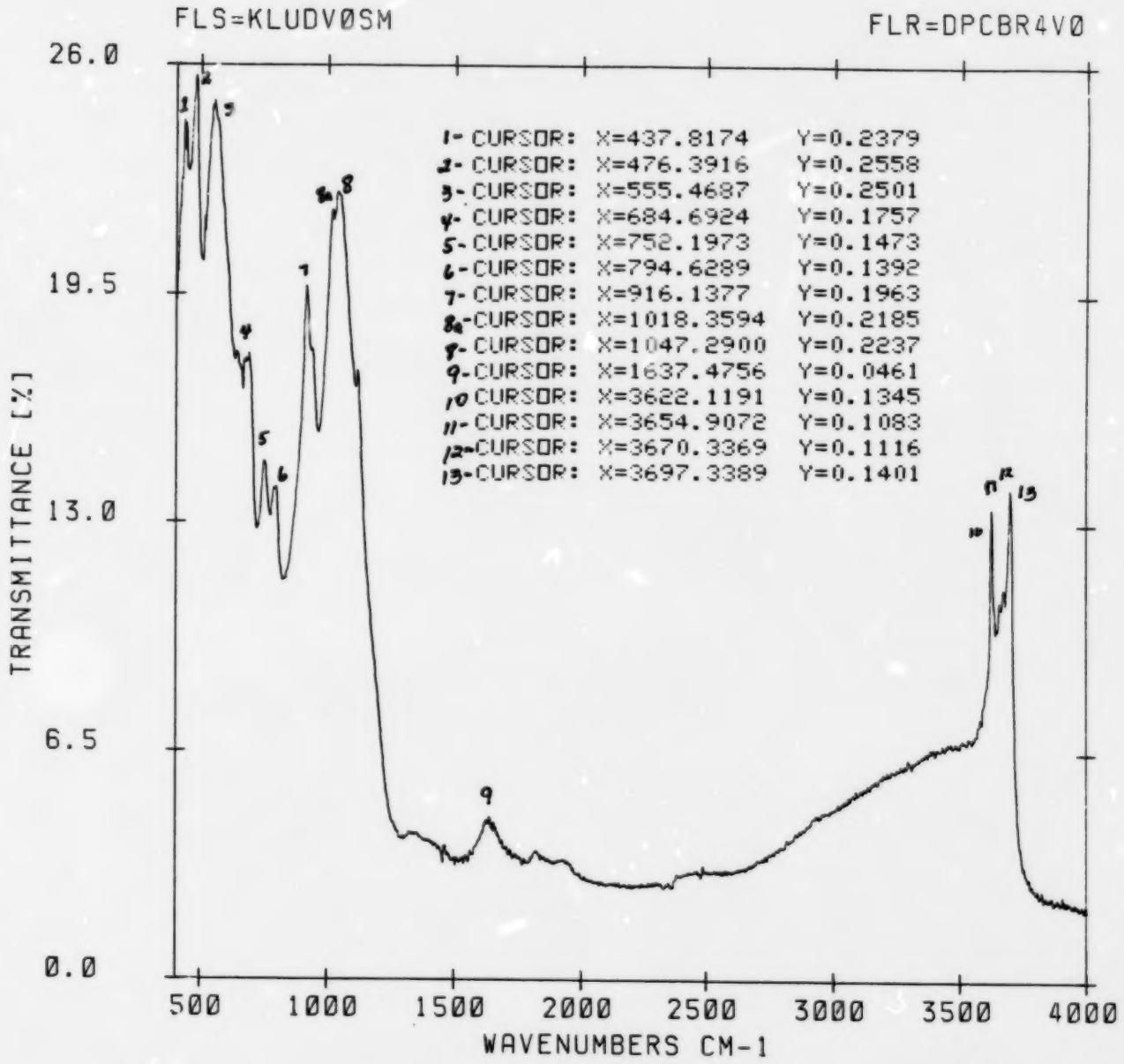

Fig. C-8. Mid-infrared photoacoustic spectrum of kaolinite.

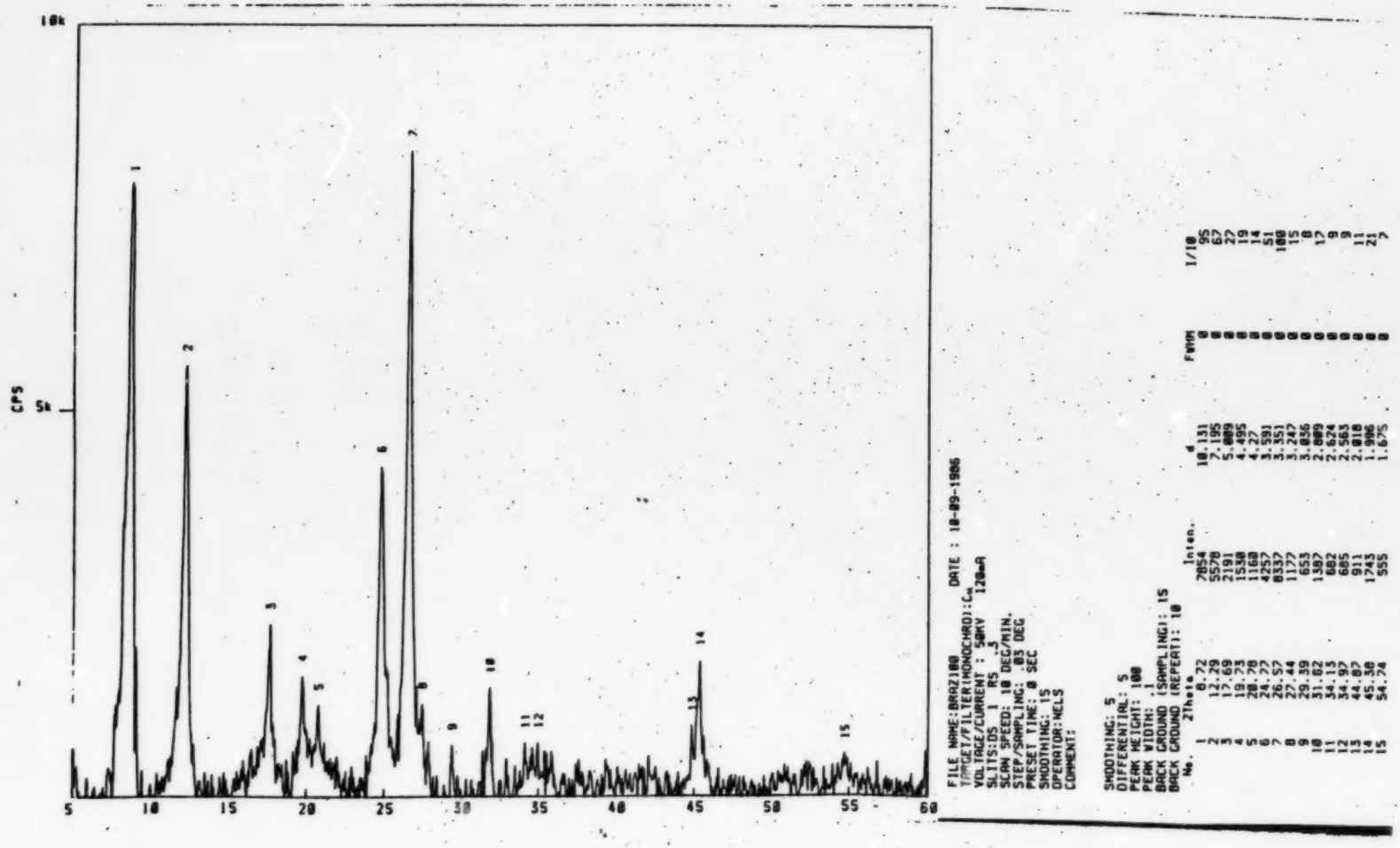

Fig. C-9. X-Ray Diffractogram of 'Aporofo F' clay.

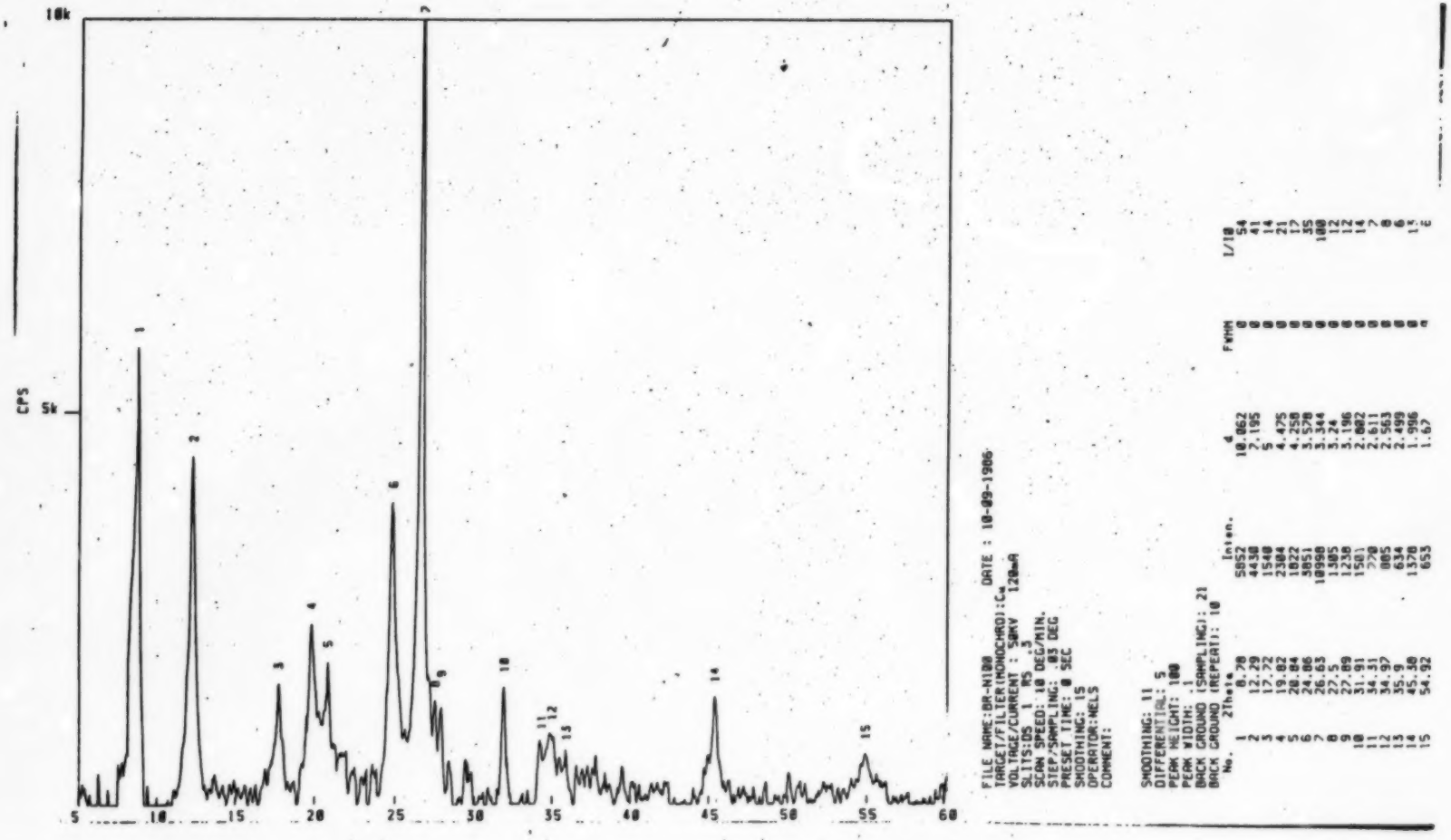

Fig. C-10. X-Ray diffractogram of 'Aporofo N' clay.